United States Department of Agriculture

Marketing and Regulatory Programs

Animal and Plant Health Inspection Service

Plant Protection and Quarantine

August 2003

STRATEGIC PLAN TO MINIMIZE THE IMPACT OF THE INTRODUCTION AND ESTABLISHMENT OF SOYBEAN RUST ON SOYBEAN PRODUCTION IN THE UNITED STATES

SOYBEAN RUST
Phakopsora pachyrhizi, P. meibomiae

Revised August 1, 2003

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EXECUTIVE SUMMARY

The 2002 report of soybean rust (*Phakopsora pachyrhizi*) damage in South America, renewed concern for the likelihood and effect of introductions of the disease into continental US ecosystems, particularly soybean production areas. Since May 2002, meetings and consultations have occurred within an ad hoc work group composed of USDA agencies representing the Animal and Plant Health Inspection Service (APHIS), Agricultural Research Service (ARS), and Cooperative State Research Extension and Education Service (CSREES), National Plant Board, stakeholders, and industry to identify an appropriate response to the introduction of the disease. Specific response components include stakeholder communication, education, and training; potential detection methods and alternatives; and mitigation measures to reduce the impact on US soybean growers once soybean rust is found in continental US growing areas. Unfortunately, technology to efficiently minimize the impact of soybean rust is not available. Management tools such as resistant varieties and registered fungicides will be needed to reduce production losses attributable this disease.

Drawing upon the experience of how infestations in Zimbabwe, South Africa, Paraguay and Brazil have progressed in the last two growing seasons, we have learned that *P. pachyrhizi* infestations have spread rapidly due to its copious urediniospore production and ability to spread by wind currents and storms. The disease also has numerous uncultivated, primarily leguminous hosts, many of which grow throughout the United States. Considering these facts, there is general agreement that attempts to contain and eradicate, the traditional response to an introduction of a serious exotic disease of a major crop, cannot be justified. Therefore, a regulatory (quarantine) would be ineffective in preventing the spread of the disease once it becomes established in the US; eradication would not be technically possible.

USDA believes that steps to prevent entry of *P. pachyrizi* in association with imported soybean products represents an important measure for delaying the establishment of ASBR into the US. This document describes the elements that require attention in order to provide a solid foundation for the response to address introduction of ASBR. Elements of the plan include development of safeguarding components for an outreach program, exclusion practices, and technology development. A successful outreach program will improve the likelihood of timely detections of the disease and subsequent implementation of mitigation measures that may limit crop loss. USDA has a leadership role in coordinating activities to prepare for the introduction of ASBR into the Nation's soybean production areas and minimizing its long range impact through **exclusion**, **outreach**, and **technology development** which will promote soybean rust management preparedness.

Exclusion

Stakeholders, including USDA, recognize that natural introductions of ASBR into the US and its soybean production system will very likely occur, the only question is when and where that will occur. In the meantime, USDA intends to delay the human assisted introduction of the disease through its safeguarding program. USDA recognizes its responsibility to prevent the introduction of foreign plant pests and diseases with the potential for adversely impacting production agriculture and the environment. APHIS-Plant Protection and Quarantine (PPQ) will continue to support permitting and inspection activities as components of its safeguarding activities thereby reducing the risk of introducing ASBR through human assisted channels. An effective program to reduce the

human assisted movement of the disease will help to provide additional time in preparing for the entry of the disease.

Outreach

The principal components for an effective outreach program include communication, education, and training programs designed for producers, handlers, field scouts, crop specialists, and others engaged in soybean production, crop management, and identification. In addition, because *P. pachyrhizi* can reproduce in many non-cultivated plants occurring throughout the US the outreach program should also target non-agricultural stakeholders.

We view the outreach program as the forum for the dissemination of information and training. This program will underpin the soybean rust detection program, development and distribution of a communication plan for the initial detection, and communication of management practices for production agriculture.

Outreach activities will require that USDA, National Plant Diagnostic Network centers, Integrated Pest Management Regional Centers, and industry develop a coordinated plan to ensure that there is a unified voice on ASBR.

Technology Development

Federal and state cooperators and the scientific community should work together to support the development of technical information to be communicated through the outreach program, especially the identification of management practices for production agriculture. Soybean producers, handlers, and scientists believe access to registered fungicides and rust resistant varieties would be of the greatest value to mitigate production losses that would be caused by the disease. In the foreseeable future, the mitigation for established infestations will rely predominantly upon the use of fungicides and the planting of early-maturing soybean cultivars. Technologies required to sample, identify, and mitigate ASBR from soybean imports that do not jeopardize product quality are required.

PURPOSE AND DISCLAIMER

Purpose

This plan has been developed to assist stakeholders in preparing for and mitigating the impact of the detection and establishment of soybean rust in US, especially in the Nation's soybean production areas. The procedures described in this document were developed by PPQ staffs through collaboration with other APHIS staff, National Plant Board, the Agriculture Research Service, Cooperative State Research, Extension, and Education Service, university scientists, and stakeholders.

Disclaimer

This document is not intended to be complete and exhaustive. The information given herein was taken from available literature and synthesized into a specialized document intended to assist further work, as stated above. Some key articles were not available at the time this was written, nor have all pertinent specialists and other members of the research community been consulted for their advice.

GENERAL INFORMATION

Action Statement

The information contained in this document is intended for use as guidance in designing a program to detect and respond to the establishment of Asian Soybean Rust (*Phakopsora pachyrhizi)* (ASBR) in the continental United States. This plan provides information on **safeguarding** efforts which involve the use of offshore strategies to prevent or slow the entry into and spread of ASBR within the U.S., **outreach** activities identify educational opportunities and tools developed and to be implemented by an array of public agencies and private organizations, and **technology development** for improved capability for detection and mitigation to support U.S. soybean production.

Background Information and Introduction

Soybean rust is caused by either of two fungal species *Phakopsora pachyrhizi,* Sydow and Sydow known as the Australasian species, and the Latin American species, *P. meibomiae* (Arthur) Arthur. Both species have been known to in Brazil, Argentina, and Paraguay. While *Phakopsora pachyrhizi* has been reported in various countries including Argentina, Australia, China, Korea, Malaysia, Indonesia, Sierra Leone, Cambodia, New Guinea, Viet Nam, Ghana, India, Japan, Nepal, Taiwan, Thailand, the Philippines, Mozambique, Nigeria, Rwanda, Uganda, United States (Hawaii only), Zimbabwe, South Africa, Brazil, and Paraguay.

Phakopsora meibomiae, is considered to be a less virulent pathogen of soybeans than *P. pachyrhizi*. It has been reported in Costa Rica, Cuba, Dominican Republic, Guatemala, Mexico, Venezuela, Bolivia, Barbados, Trinidad, Chile, St. Thomas, Brazil, and Colombia. The first detection of soybean rust in the United States was *P. meibomiae* reported in Puerto Rico in 1976 and this species has proven to be a weak pathogen on soybean. Although this document deals with the more virulent pathogen, *Phakopsora pachyrhizi* detections of *Phakopsora meibomiae* will be assessed consistent with PPQ policy.

Phakopsora pachyrhizi, which is much more virulent on soybeans, was reported in Hawaii in 1994. Recent introductions of *P. pachyrhizi* in other parts of the world show a rapid spread causing severe damage in Zimbabwe (2000), South Africa (2001), Paraguay (2001), Argentina (2002), and Brazil (2002) where yield losses from this species have been reported from 10-80%.

There are 30 species in 17 genera of legumes, other than soybean reported to be hosts for soybean rust in nature, with 60 species in 26 genera that were successfully inoculated under laboratory conditions. One widespread host in the United States is kudzu, *Pueraria lobata* that could serve as an inoculum reservoir for soybean rust, thereby maintaining an inoculum source that may play a significant role in ASBR epidemiology. There are a variety of other important hosts that are leguminous crops or weeds that have shown varying degrees of susceptibility to both species of soybean rusts.

P. pachyrhizi introduced to the United States soybean production areas could cause large crop and economic losses to soybean growers and associated industries. Other leguminous crops may also suffer losses (See PRA Table to be added). Soybean rust spreads primarily by wind-borne spores within and between fields and across regions depending upon prevailing winds and environmental conditions conducive to disease development. Recent infestations in Africa have been widespread in the same year they were first detected. However in South America, 2 to 3 years were required from the time of detection to widespread onset. Therefore, it is unlikely that an eradication program designed to eliminate the pathogen or disease upon its detection in the continental United States would be appropriate or effective.

Commercial U.S. soybean cultivars are not resistant or tolerant to *P. pachyrhizi*. However, fungicides have been used effectively in other countries to mitigate the impacts on soybean production. There are currently two fungicides labeled for rust on soybeans in the U.S. Effective dosage rates and application methods for soybean rust require further development. Efforts are being made by chemical companies, researchers, and the soybean industry to find additional efficacious chemicals, formulations, and application rates and methods. Efforts are underway by states to attain Section 18 registrations for use in the U.S. that are presently in use offshore.

SAFEGUARDING COMPONENTS AND SUPPORT NEEDS

Exclusion

Natural introductions of soybean rust into the US and its soybean production system will very likely occur. However, a fundamental question involves where and what the disease dynamics will be when ASBR arrives. In the meantime, USDA intends to delay the human assisted introduction of the soybean rust through its exclusion program. USDA recognizes its responsibility to prevent the introduction of foreign plant pests and diseases with the potential for adversely impacting production agriculture and the environment. PPQ will continue to support international information gathering, permitting and inspection activities as components of its exclusion and safeguarding activities, thereby reducing the risk of introducing ASBR through human assisted channels. An effective program to reduce the human assisted movement of the disease will help to provide additional time in preparing for the entry of the disease. At present, all vegetatively propagated members of the Fabaciae are prohibited entry under Q-37.

USDA-APHIS-PPQ has legislative authority under the Plant Protection Act to control the importation of commodities that may serve as pathway for the introduction of foreign plant and animal pests and diseases. The agency administers this responsibility through the agricultural quarantine inspection program at the Nation's international ports of entry and through PPQ permitting procedures.

To support exclusion activities for the safeguarding component APHIS will:

- ensure PPQ continues to prohibit or require appropriate treatment of articles moving into the United States that may serve as a pathway for the introduction of ASBR. However, once the disease has become established in the United States, APHIS will review its policy regarding importation of soybean rust infected material consistent with its international trade obligations;

- liaison with Department of Homeland Security, intelligence gathering agencies, CSREES, National Plant Diagnostic Network, and other appropriate organizations to reduce the risk of the introduction soybean rust through a terrorist event;

- ensure that International Services provide periodic updates about soybean rust situations occurring in countries that may serve as a pathway into the US;

- identify mitigation elements for offshore practices to reduce risk of entry.

- create a Soybean Rust Detection Assessment Team to be dispatched to the initial detection site to conduct an incident evaluation.

Outreach

The principal components for an effective outreach program include communication, education, and training programs and materials designed for producers, handlers, field scouts, crop specialists, extension agents and others engaged in soybean production, crop management, and identification. In addition, because soybean rust affects many non-cultivated hosts occurring throughout the US the outreach program should include non-agricultural stakeholders.

We view the outreach program as the forum for the dissemination of information and training related to soybean rust. This program will serve to support the soybean rust detection program, provide a forum for communication about the status of the disease, and disseminate information about current best management practices.

USDA proposes to support and monitor detection activities for soybean rust through an extensive information and education program enhanced by training and the distribution of technical program aides. The goal of the program is to provide sufficient information that producers, state cooperators, field scouts, extension agents, and others that spend time in the “field” would recognize the symptoms of soybean rust. Those individuals would also be instructed how to take and submit samples for identification to local or regional diagnostic centers or report detection to local Federal/State officials (Appendix I and Appendix II).

The planning and implementation of a surveillance program will require support for the following activities for survey:

- CSREES in cooperation with ARS and APHIS will develop technical information for survey training programs and program aides for distribution to stakeholders and interested parties;

- CSREES will identify and activate distribution systems to communicate technical information;

- CSREES in cooperation with APHIS and ARS will development a rust screening and identification system for submitted samples and information sharing about the process of submission;

- PPQ, State Plant Health Directors will have the responsibility to ensure initial detections of soybean rust are reported into the National Agricultural Pest Information System (NAPIS).

Unfortunately, the United States will likely experience the introduction and establishment of soybean rust. It’s therefore necessary to prepare a communication plan for advising Federal, state, producers, and other stakeholders that the disease has been found, refreshing the dialog regarding appropriate mitigation measures and future management practices.

- APHIS will be responsible for ensuring Federal and State officials, industry, and other stakeholders are alerted to initial detections of soybean rust in the US. This communication plan is shown in **Appendix III.**

Work is underway in cooperation with EPA and industry to obtain appropriate labels for fungicides Continued and/or increased research to develop integrated ASBR management programs are necessary.

The development of recommendations to mitigate the impact of soybean rust on soybean production needs support by:

- CSREES, with cooperation from APHIS and ARS will develop information for use in preparing technical training programs and program aides describing actions to reduce crop damage;

- CSREES will identify and activate distribution systems to communicate technical information;

Technology Development

The outreach program will recommend measures that could assist in mitigating the adverse impacts of the disease on soybean production. Currently the only available means for reducing production losses caused by soybean rust is timed fungicidal applications. The agrichemical industry, with assistance from individual states, APHIS, the Environmental Protection Agency and others will obtain registration for fungicides that have proven efficacy and have been successfully used against soybean rust in other countries. Options for obtaining an exemption for certain compounds are currently being pursued as well. See **Appendix IV** for management practices information.

Federal and state cooperators and the scientific community should work together to support the development of technical information regarding management practices to minimize the impact of soybean rust on the production agriculture community. Soybean producers and handlers and scientists believe access to registered fungicides and rust resistant varieties would be of the greatest value to mitigate production losses caused by the disease.

Disease resistant or tolerant varieties have long been relied on as a means of reducing the economic impact of a serious plant disease. Field losses of 10%-80% have been reported in soybeans infected with ASBR. Certainly, rust resistant varieties of soybeans would be very valuable in overcoming economic losses caused by the disease. Efforts continue toward development of cultivars that are resistant to *P. pachyrhizi*

A valuable tool in the management of soybean rust will be models for predicting outbreaks and tracking annual occurrences of the disease. These models will facilitate grower decisions for disease surveillance, monitoring, and timing of fungicide applications

- ARS and CSREES in cooperation of seed companies will develop commercially acceptable rust resistant or tolerant soybean varieties to minimize the economic impact of the establishment of soybean rust on the industry. International activities toward development of resistant cultivars will be monitored.

- ARS and CSREES will engage in research to characterize the epidemiology of ASBR required to develop forecasting that will serve as the technical basis for an early warning system to assist producers in management of the disease. This will include temporal and spatial analyses relevant to understanding the disease dynamics. This information will also serve as the technical basis for effective mitigation systems.

- APHIS and the USDA Office of Pest Management Policy, in collaboration with the Environmental Protection Agency will facilitate states and industry efforts in obtaining label revisions and/or approvals for US registered fungicides for use against soybean rust.

Appendix I

DETECTION SURVEY PROCEDURES

There is concern in soybean producing states about the introduction of Soybean rust and its potential economic impact. Based on infestation scenarios experienced in southern Africa and South America, it is much more likely that soybean rust will enter the United States by wind borne spores via wind currents form West Africa or northern South America and the Caribbean. It is also believed by scientists that the infestation will likely first be found in the Gulf Coast states.

The survey effort will be collaborative effort by Federal, State and stakeholders to detect soybean rust in the United States. The survey will depend on growers, handlers, field scouts, and others with soybean rust training or information that work and play out of doors. Because the disease has numerous hosts, cultivated and non-cultivated the disease is likely to be found anywhere where host material is available. Utilizing individuals with an understanding and awareness of the disease and its symptoms, knowledge of the local geography and working in soybean and other bean fields, and traversing the landscape increases the likelihood for detection. With such a corps of individuals more areas could be surveyed, larger geographical areas could be surveyed, areas could be surveyed more frequently, some areas would be under continual surveillance, and surveys could be conducted throughout the entire growing period.

Detection Survey

A systematic Cooperative Agricultural Pest Survey (CAPS) funded national survey is not planned for the detection of soybean rust. However, CAPS funding will be considered for proposals to establish collaborations and networks with growers, field scouts, scientists, researchers, and organizations that work in soybean fields or environs where soybean rust host material is present; training to identify symptoms of the disease; training for diagnosticians to identify the disease; and preparation and distribution of program aides or other educational material. Detection of soybean rust will be reported into the National Agriculture Pest Information System (NAPIS) by PPQ State Plant Health Directors or appropriate CAPS cooperator.

Detection surveys will normally be carried out by “surveyors” provided with information about the disease and its symptoms at any site where available host material exists. Growers, scientists, researchers, and others interested in detecting soybean rust should be encouraged to plant sentinel plots with early maturing soybean cultivars, prior to the traditional planting time as areas to bias the initial survey. Soybean experimental research plots are also areas to include in detection surveys. Soybean rust has shown some susceptibility on other bean species and some commercial plantings of these should be checked in detection surveys as well.

The weed kudzu occurs in large areas throughout the southern United States and can serve as a place for early detection surveys. We do not recommend the use of planting kudzu as a sentinel crop because of its invasiveness, but surveyors in kudzu-infested areas will be encouraged to inspect naturally growing plants for presence. It is thought that in Zimbabwe and Brazil, soybean rust may build up inoculum in hosts adjacent to soybean fields and serve as a reservoir when soybeans are not in the susceptible stages.

Survey procedures will vary depending on the feasibility of surveying plants in the field, season, environmental conditions and other factors. The actual inspection will consist of a thorough visual examination of soybean plants in the field and of other host plants in the vicinity of the areas being surveyed. It is expected that individuals working in the field or traversing the environs would see visual signs of infection and either collect samples or report the location of the damage to local extension office. Information from South America indicates a distinct yellowing or browning of fields with high infection rates, and this character might be useful in pin-pointing to areas needing further investigation.

For early detection, check for pustules (blisters or lesions) and chlorosis (yellowing) on the undersides of the lower leaves of soybean plants before flowering. *P. pachyrhizi* is a monocyclic, obligate parasite that infects petioles, pods and stems of the plant, especially the undersides of leaflets. Inspection can begin at anytime during growth, however inspection of plants with well developed leaflets would be preferred. The lesions are fewer and smaller on the upper leaf surfaces. The disease is detected by inspecting the undersides of the leaves for uredinial pustules that are powdery and buff or pale brown. As the plants mature and the frequency of rainfall events increase, the severity of the disease increases as well. Lesions will be found in the middle and upper canopy in more advance infections. Eventually, defoliation and leaf drop will occur.

Collection of Specimens

The instructions for surveyors, growers, extension personnel, crop consultants, and field scouts encountering soybean rust like symptoms are detailed at the PPQ Soybean Rust Pest Alert website. The procedure is to place leaf, stem, or pod samples in a self locking plastic bag and stored cool conditions or sealed in a paper bag if it must be kept in ambient conditions to prevent mold growth. Ensure that adequate material is collected to increase the likelihood of finding spores. Care should be taken to ensure the outside of the bags are not contaminated by the sample. Record collection information (date, location of the field, host plant and collector's name) on a form designed for that purpose or on a piece of paper included with the sample. An example, PPQ form 391 indicates pertinent collection information that should be collected (See exhibit attached to Appendix I).

Submit the sample through the State Department of Agriculture's diagnostic service or the land grant university's diagnostic laboratory in the state collected. These laboratories will screen samples to assure they are not diseases that can be confused with soybean rust.

A list of university diagnostic laboratories is available at the American Phytopathological Societies directory website:
http://www.apsnet.org/directories/univ_diagnosticians.asp

State Department's of Agriculture contacts are available at the National Plant Board website: http://www.aphis.usda.gov/npb/npbmemb.html

EXHIBIT

Specimen submission from for diagnostic laboratory to the APHIS National Mycologist.

This report is authorized by law (7 U.S.C. 147a). While you are not required to respond your cooperation is needed to make an accurate record of plant pest conditions.

FORM APPROVED
OMB NO. 0579-0010

U.S. DEPARTMENT OF AGRICULTURE
ANIMAL AND PLANT HEALTH INSPECTOIN SERVICE

SPECIMENS FOR DETERMINATION

Instructions: Type or print information requested. Press hard and print legibly when handwritten. Item 1 assign number for each collection beginning with year, followed by collector's initials and collector's number. Example (collector, John J. Dingle); 83-JJD-001. Pest Data Section - Complete Items 14, 15 and 16 or 19 or 20 and 21 as applicable. Complete Items 17 and 18 if a trap was used.

FOR IIBIII USE
LOT NO.
PRIORITY

1. COLLECTION NUMBER

2. DATE — MO | DA | YR

3. SUBMITTING AGENCY — ☐ State Cooperator ☐ PPQ ☐ Other ....

INTERCEPTION SITE

4. NAME OF SENDER

5. TYPE OF PROPERTY *(Farm, Feedmill, Nursery, etc.)*

6. ADDRESS OF SENDER

ZIP

7. NAME AND ADDRESS OF PROPERTY OR OWNER

COUNTRY/
COUNTY

8. REASON FOR IDENTIFICATION *("X" ALL Applicable Items)*

A. ☐ Biological Control (Target Pest Name)
B. ☐ Damaging Crops/Plants
C. ☐ Suspected Pest of Regulatory Concern (Explain in remarks)
D. ☐ Stored Product Pest
E. ☐ Livestock, Domestic Animal Pest
H. ☐ Possible Immigrant (Explain in remarks)
J. ☐ Survey (Explain in remarks)
L. ☐ Other (Explain in remarks)

9. IF PROMPT OR URGENT IDENTIFICATION IS REQUESTED, PLEASE PROVIDE A BRIEF EXPLANATION UNDER "REMARKS".

10. HOST INFORMATION
NAME OF HOST *(Scientific name when possible)*

11. QUANTITY OF HOST
NUMBER OF ACRES/PLANTS
PLANTS AFFECTED *(Insert figure & indicate number or percent)* ☐ Number ☐ Percent

12. PLANT DISTRIBUTION
☐ LIMITED
☐ SCATTERED
☐ WIDESPREAD

13. PLANT PARTS AFFECTED
☐ Leaves, Upper Surface ☐ Trunk/Bark ☐ Bulbs, Tubers, Corms ☐ Seeds
☐ Leaves, Lower Surface ☐ Branches ☐ Buds
☐ Petiole ☐ Growing Tips ☐ Flowers
☐ Stem ☐ Roots ☐ Fruits or Nuts

14. PEST DISTRIBUTION
☐ FEW
☐ COMMON
☐ ABUNDANT
☐ EXTREME

15. ☐ INSECTS ☐ NEMATODES ☐ MOLLUSKS

NUMBER SUBMITTED	LARVAE	PUPAE	ADULTS	CAST SKINS	EGGS	NYMPHS	JUVS.	CYSTS
ALIVE								
DEAD								

16. SAMPLING METHOD

17. TYPE OF TRAP AND LURE

18. TRAP NUMBER

19. PLANT PATHOLOGY - PLANT SYMPTOMS *("X" one and describe symptoms)*
☐ ISOLATED ☐ GENERAL

20. WEED DENSITY
☐ FEW ☐ SPOTTY ☐ GENERAL

21. WEED GROWTH STAGE
☐ SEEDLING ☐ VEGETATIVE ☐ FLOWERING/FRUITING ☐ MATURE

22. REMARKS

23. TENTATIVE DETERMINATION

24. DETERMINATION AND NOTES *(Not for Field Use)*

FOR IIBIII USE
DATE RECEIVED
NO.
LABEL
SORTED
PREPARED
DATE ACCEPTED
RR

PPQ FORM 391
(JUL 86)

Previous editions are obsolete.

Appendix II

IDENTIFICATION PROCEDURES

Correct and proper identification is the key to determining whether a program will be attempted and, if so, the extent, direction, and magnitude of the program. It will also help determine program changes and program failures.

Identification Characters

Symptoms of soybean rust appear identical regardless if they are caused by *Phakopsora pachyrhizi* or *P. meibomiae*. Host plants infected with soybean rust first show small lesions which gradually increase in size, turning gray to tan or brown. They become polygonal shape restricted by leaf veins and may eventually reach 2 to 3 square millimeters.

Infection begins on the lower first leaves of plants and appearing as chlorotic or mosaic like areas with uredinia observed usually at or after the plant flowering stage. Lesions may appear on the petioles, stems, pods, but are most common on the leaves, especially on the lower surfaces. As the plant matures and sets pods, infection progresses rapidly under the right environmental conditions (moisture, high humidity and heat) to cause high rates of infection in the middle and upper leaves of the plant. Clouds of spores have been observed within and or above canopies of highly infected plant stands.

Plants show two different lesion reactions to infection by soybean rust. Tan lesions consist of small uredinia surrounded by slightly discolored necrotic areas on leaf surfaces. Early stages show an ostiole, or small hole, where urediniospores emerge. As uredinia become larger, they release masses of tan colored urediniospores that give the appearance of light brown to white raised areas. Uredinial pustules become more numerous with advancing infection and often they will coalesce forming larger pustules that break open releasing masses of urediniospores.

The other type of lesion that occurs as a different reaction of the plant to soybean rust infection is the reddish-brown lesion. These lesions have larger areas of necrosis that is reddish brown surrounding a very limited number of uredinia that usually have few urediniospores visable on the surface.

Early symptoms of soybean rust symptoms can be easily be confused with bacterial pustule, *Xanthomonas campestris pv. phaseoli* (Smith) Dye or bacterial blight, *Psuedomonas glycinea* Coerper and brown spot (S*eptoria glycines)*. These bacterial diseases also occur often on the underside of soybean leaves causing a raised, light brown blister within a lesion. These bacterial leaf lesions vary from small specks to large irregular brown areas which form when small lesions coalesce. A hand lens or dissecting microscope are usually used to distinguish bacterial disease symptoms from rust, but early stages of both diseases are difficult to distinguish if no spores or bacteria are evident.

The more advanced raised blister-like pustules of the bacteria resemble the uredial cones, (or pustules) of the rust but can be distinguished by two microscopic characteristics. The uredial pustules open through a round ostiole while the bacterial pustule is torn across by a fissure. Also, white clumps of urediniospores can generally be observed lodged on top of the uredial cone sometimes emerging in columns. Breaking open the pustule will reveal large numbers of urediniospores. These rust spores can be identified by mounting them on a microscopic slide and examining them under a compound microscope. Bacterial pustule will produce bacterial streaming when sectioned infected material is observed under a compound microscope and no spores will be observed.

Photographs of soybean rust symptoms and urediniospore morphology are available on PPQ's Pest Detection website at:
http://www.aphis.usda.gov/ppq/ep/pestdetection/soybean_rust/soybeanrust.html

Examination of the morphology of soybean uredinia and urediniospores found in rust cone pustules cannot be used to confidently to distinguish *Phakospora pachyrhizi* from *P. meibomiae*. Differences can be seen to distinguish them based on the telia and teliospores however these are seldom seen in nature. Therefore, the only definitive methods for correct identification of soybean rust are molecular techniques (PCR).

The Agriculture Research Service laboratories in Ft. Detrick, Maryland have developed primers for polymerase chain reaction (PCR) identification of *Phakopsora pachyrhizi* and *P. meibomiae* and made them available to the USDA, APHIS, PPQ National Mycologist in Beltsville, Maryland. In using PCR techniques, DNA is extracted from spore or infected leaf samples, ground up and purified before being analyzed for the presence of key sequences of DNA that distinguish it from related species

Diagnostic Laboratory Instructions

If university or state department's of agriculture laboratories determine the samples submitted to be *Phakopsora* spp. on soybean or another leguminous hosts, further identification to the species (*P. meibomiae* or *P. pachyrhizi*) level will be necessary. There are no *Phakopsora* species on legume hosts recorded in the continental United States. A new *Phakopsora* record, because of its potential economic importance, will require verification by the USDA, APHIS National Mycologist in Beltsville, Maryland. Additionally, species determination of urediniospores is only possible through polymerase chain reaction (PCR) procedures, the primers of which currently reside with USDA.

Diagnostic laboratories should contact Drs. Mary Palm (301) 504-5327 or John McKemy at (301) 504-5280 if *Phakopsora* spp. on a legume host is found. At the same time, the State department of agriculture in the state detected should be contacted before samples are forwarded. After consultation with Drs. Palm or McKemy, samples should be properly secured and sent overnight freight to:

Dr. Mary Palm
USDA, APHIS, PPQ
Bldg. 011A, Room 329, BARC-West
10300 Baltimore Blvd.
Beltsville, MD 20705-2350

Appendix III

COMMUNICATION PLAN

Once soybean rust is detected in the United States, prompt communication with all affected and interested parties is essential. After PPQ's National Mycologist confirms the disease, PPQ and APHIS' Legislative and Public Affairs (LPA) staff will communicate the detection in the following manner:

- Plant Protection and Quarantine will notify the leadership of the National Association of State Departments of Agriculture through a conference call.

- Plant Protection and Quarantine will notify the President of the National Plant Board through a telephone call.

- Plant Protection and Quarantine will notify CSREES National Plant Diagnostic Network through e-mail.

- Plant Protection and Quarantine will notify the United Soybean Board through a telephone call.

- Plant Protection and Quarantine will notify the American Phytopathological Society of the soybean rust detection through email.

- LPA will issue a press release announcing the detection of soybean rust. This may be done jointly with the affected State and/or the United Soybean Board.

- LPA will distribute press release to all interested soybean and industry publications. LPA will coordinate answers to media inquiries.

- LPA's legislative personnel, along with USDA's Office of Congressional Relations, will contact representatives in the affected state(s), along with other interested stakeholders.

- PPQ will post notification on soybean rust web site.

Appendix IV

MANAGEMENT PRACTICES

The occurrence of this disease will have an impact on the production of soybeans in the United States. Because of the severity of the disease and costs to control field infections it is likely the production of soybeans in southern-most states could become unprofitable. Growers can expect an increase in production costs related to fungicides and their application to protect the crop.

It is suggested that prior to the establishment of the disease, growers consider removing non-cultivated soybean rust host material from field borders. The removal of this material will reduce the amount of hosts available, thereby reducing the amount of available host material to initiate an infection while decreasing the availability of sites for inoculum buildup.

The best long term strategy for minimizing the effects of soybean rust in the United States is in the development of resistant varieties. There are thousands of plant lines of soybean in germplasm repositories and screening for soybean resistance has been on-going for several years in other countries and the US in the containment facilities at the Agriculture Research Services Foreign Disease-Weed Science Research Unit in Ft. Detrick, Maryland. However, the availability of cultivars with good resistance and other characters desired in soybean for commercial production are still 5 to 7 years away.

Fungicides have been shown to be effective in controlling soybean rust in Zimbabwe, South Africa and Brazil. Efforts to obtain a Federal Crisis Exemption for some candidate fungicides are currently being made at the Department level and the major chemical companies that already have fungicides on the market are making efforts to get labeling changes approved through EPA.

Once an effective fungicide or fungicides, are available for use by growers, a recommendation would be made to extension scientists, crop consultants and growers to have sentinel plantings placed strategically in soybean growing areas that would allow for early detection of the disease, which would facilitate producer decisions about protectant applications of fungicides. Since soybean rust manifests primarily on maturing plants, the sentinel plantings should occur about 3 weeks before the commercial crop. This provides an opportunity to observe the first signs of the disease on the sentinels thereby allowing time to effect control of the pathogen in commercial plantings before the disease becomes epidemic. An early protectant application of fungicide will be needed around flowering time when sentinel plants are infected. Subsequent applications may be necessary as the crop matures and the disease begins to intensify.

Dr. Clive Levy, with the Commercial Farmer's Union of Zimbabwe reported that once an infestation of soybean rust is detected, if early enough, effective control was obtained with carefully timed fungicide applications. Detection early in the season with properly timed application of fungicides appears to present the best alternative for controlling soybean rust in the United States. In areas of high rust severity, the first application is at first flowering and then two more applications in 21 day intervals thereafter. In areas with lower severity, the last application is not necessary. In Zimbabwe some farmers found a schedule of first applications 50 days after planting, then at 70 and 90 days after planting. In all cases, but especially in the first applications, it is most effective to apply the fungicides in such a manner that the lower canopy is receives treatment.

Currently there are no fungicides registered for soybean rust control in the United States. It is important that more than one fungicide be available in the event they are needed for soybean rust control so that resistance development is minimized.

Once the disease is established in the United States, a valuable tool to assist in the management of soybean rust would predictive models that would forecast the occurrence and movement of the disease in the nation's soybean crop. This information would be extremely useful to producers and others for surveillance and monitoring activities and timely applications of fungicides.

Through cooperation, education, and training growers will be provided with the tools to make informed decisions about managing soybean rust and soybean production.

Appendix V

SUMMARY OF SAFEGUARDING RECOMMENDATIONS

- **Exclusion**

  - ensure PPQ continues to prohibit or require appropriate treatment of articles moving into the United States that may serve as a pathway for the introduction of soybean rust. However, once the disease has been introduced into the United States, APHIS will review its policy regarding importation of soybean rust infected material consistent with its international trade obligations;

  - liaison with security agencies to reduce the risk of the introduction soybean rust through a terrorist event;

  - ensure that International Services provide periodic updates about soybean rust situations occurring in countries that may serve as a pathway into the US;

  - establish SBR Detection Assessment Team as first responders for incident analysis.

- **Outreach**

(The planning and implementation of a surveillance program will require support for the following activities.)

  - CSREES in cooperation with ARS and APHIS will develop technical information for survey training programs and program aides for distribution to stakeholders and interested parties;

  - CSREES will identify and activate distribution systems to communicate technical information;

  - CSREES in cooperation with APHIS and ARS will development a rust screening and identification system for submitted samples and information sharing about the process of submission;

  - PPQ, State Plant Health Directors will have the responsibility to ensure initial detections of soybean rust are reported into the National Agricultural Pest Information System (NAPIS).

  - PPQ in cooperation with ARS and CSREES will review existing air current data in an effort to correlate potential dispersal of the disease from known infected areas to potential survey locations in the United States and or natural land pathway movement northward.

(The development of recommendations to mitigate the impact of soybean rust on soybean production needs support by:)

- CSREES, with cooperation from APHIS and ARS will develop information for use in preparing technical training programs and program aides describing actions to reduce crop damage;

- CSREES will identify and activate distribution systems to communicate technical information;

- APHIS and the USDA Office of Pest Management Policy, in collaboration with the Environmental Protection Agency and industry, to pursue obtaining label revisions and/or approvals for US registered fungicides for use against soybean rust;

- APHIS in collaboration with EPA, scientists, and industry will develop technical application information (dosage, rate, etc.).

- **Technology Development**

  - ARS and CSREES with cooperation of seed companies will develop commercially acceptable rust resistant or tolerant soybean varieties to minimize the economic impact of the establishment of soybean rust on the industry.

  - CSREES and PPQ will support development of an early warning system to assist producers in management of the disease.

Appendix VI

SOYBEAN RUST HOSTS

Because of confusion over the taxonomy of the pathogens causing soybean rust, *Phakopsora meibromiae* and *Phakopsora pachyrhizi*, the list of the hosts of *Phakopsora pachyrhizi* may be incomplete; however, according to various recent references, a large number of legume species are host plants for *Phakopsora pachyrhizi*. *Glycine max*, *G. sojae*, *Pachyrhizus erosus*, *Pueraria lobata*, and *Vigna unguiculata* are the principle hosts (CABI, 2001). The following table (e-mail from Hartman citing Tschanz, 1985 & 1982; Ono *et al*., 1992; use information from Bailey & Bailey, 1976) lists legume species that develop rust symptoms and uredinia and urediniospores when inoculated with *Phakopsora pachyrhizi*:

Scientific Name Common Name
Alysicarpus glumaceus Alyce clover (Naturalized in West Indies and FL?)
Cajanus cajan Cajan, pigeon pea Widely cultivated in trop. countries
Centrosema pubescens Butterfly pea Frequent in fields; W. Indies & Mex.
Crotalaria anagyroides Rattlebox Tropical northern South America
Delonix regia Royal Poinciana Wide-branching tree
Glycine canescens Soybean relative
G. *clandestina* Soybean relative
G. falcata Soybean relative
G. max Soybean Major agricultural crop in US
G. tabacina Soybean relative
Lablab purpureus Hyacinth bean (*Dolichos vablab*)
Lotus americana (Not in *Hortus Third*)
Lupinus hirsutus Blue lupine (Annual; southern Europe)
Macroptilium atropurpureum Siratro; purple bean Grows wild in Cen. and S. America
Macrotyloma axillare (Not in *Hortus Third*)
Medicago arborea Medic (Shrub; southern Europe)
Melilotus officinalis Yellow sweet clover Eurasia; naturalized in N. America
M. speciosus (Not in *Hortus Third*)
Mucuna cochinchinesis Velvetbean relative
Neonotonia (Glycine) wrightii Glycine (Old World probably)
Pachyrhizus erosus Yam bean; jicama C. America; naturalized in south FL
Phaseolus lunatus Butter bean, lima bean Tropical SA: important edible bean
P. vulgaris Kidney bean; green bean Tropical America; widely cultivated
Rhynchosia minima (Not in *Hortus Third*) Creeping tropical weed
Sesbania exaltata Colorado River hemp NY to FL; west to southern CA
S. vescaria (Not in *Hortus Third*)
Trigonella foenum-gracecum Fenugreek (Asia & southern Europe; forage)
Vigna unguiculata Cowpea, black-eyed pea Widely planted in warm regions
There are additional hosts (Ono *et al*., 1992).
Kudzu, *Pueraria lobata*, is a host; in addition,
Pueraria phaseoloides is a host (McBride, 1998; Ono *et al*., 1992). Because kudzu is a common weed in the southeastern United States, it might serve as a continual source of inoculum.

Appendix VII

SELECTED REFERENCES FOR FURTHER INVESTIGATION

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